

CLAIMS

What is claimed is:

1. A breast scanning system configured to scan a breast of a patient, comprising:

a) a bath configured to contain a medium;

b) transducer arrays, disposable in the bath, configured to transmit and receive ultrasound signals;

c) a horizontal table, disposable over the bath, configured to receive the patient thereon, having an aperture formed in the table and positionable over the bath configured to receive the breast of the patient pendent therethrough; and

d) the table and the bath being linearly vertically displaceable with respect to one another between 1) a lowered position where the table is adjacent the bath configured to position the breast within the bath, and 2) a raised position where the table is spaced-above the bath configured to elevate the breast above the bath; and

e) means for maintaining the table in the raised position with the table spaced-above the bath.

2. A device in accordance with claim 1, wherein the means for maintaining the table further comprises:

at least one column supporting the table.

3. A device in accordance with claim 2, wherein the means for maintaining the table further comprises:

a motor, coupled to the at least one column, to raise and lower the at least one column, and thus the table.

4. A device in accordance with claim 1, further comprising:

a plurality of table inserts, each insertable into the table and each having a different sized aperture formed therein.

5. A device in accordance with claim 1, further comprising:

an annular projection, formed around the aperture in the table, and extending beyond a lower surface of the table.

6. A device in accordance with claim 1, further comprising:

a chamfer, bevel or radius formed in the table around the aperture.

7. A device in accordance with claim 1, further comprising:

5 a counter-bore, formed in a lower surface of the table around the aperture,
sized to receive an upper portion of the bath when the table is in the lowered position.

8. A device in accordance with claim 1, wherein the medium includes a liquid; and
further comprising:

10 a preconditioning tank, fluidly coupled to the bath, configured to precondition
the liquid prior to being introduced into the bath; and
means for transferring liquid from the preconditioning tank to the bath.

9. A device in accordance with claim 8, further comprising:

15 a heater, coupled to the preconditioning tank; and
a thermocouple, associated with the preconditioning tank and operatively
coupled to the heater.

10. A device in accordance with claim 8, further comprising:

20 a de-gaser, coupled to the preconditioning tank.

11. A device in accordance with claim 8, wherein the de-gaser further includes:

a recirculation pump, coupled to the preconditioning tank in a circulation
circuit to pump liquid from the preconditioning tank back into the preconditioning
tank; and

25 at least one orifice, disposed in the circulation circuit having a diameter less
than a diameter of the circulation circuit, and configured to introduce a pressure
differential across the at least one orifice.

12. A device in accordance with claim 8, further comprising:

30 a de-ionizer, coupled to a liquid supply line to the preconditioning tank.

13. A device in accordance with claim 8, further comprising:

a reservoir, fluidly coupled to the preconditioning tank, configured to contain
an antibacterial or antiviral agent; and

a metering pump, coupled between the reservoir and the preconditioning tank.

14. A device in accordance with claim 1, wherein the medium includes a liquid; and further comprising:

- 5 a heater, associated with the bath, and configured to maintain a desired temperature of the liquid within the bath; and
 a thermocouple, associated with the bath and operatively coupled to the heater.

15. A device in accordance with claim 1, further comprising:

- 10 an annular channel, disposed around an upper edge of the bath.

16. A device in accordance with claim 15, further comprising:

- a liquid sensor, disposed in the channel.

17. A device in accordance with claim 1, further comprising:

- 15 a seal, compressible between the bath and the table in the lowered position.

18. A device in accordance with claim 1, further comprising:

- a pinch sensor, disposed between the bath and the table.

19. A device in accordance with claim 1, further comprising:

- means for securing the breast within the bath.

20. A device in accordance with claim 1, further comprising a breast retention
25 assembly including:

- a breast magnet with a breast connector configured to secure the breast magnet to the breast of the patient; and

- a bath magnet, disposed in the bath and magnetically coupleable to the breast magnet when the table is in the lowered position.

21. A device in accordance with claim 20, wherein the breast retention assembly
further comprises:

- a beveled cup, associated with one of the breast or bath magnets, to center the breast or bath magnets.

22. A device in accordance with claim 20, further comprising:
a rod, attached to the bath magnet and vertically movable within the bath.

5 23. A device in accordance with claim 1, further comprising:
a laser pointer, associated with the bath, configured to project a light beam
onto the breast at an area of interest.

10 24. A device in accordance with claim 1, further comprising:
a camera, associated with the bath, configured to provide an image of the
breast.

15 25. A device in accordance with claim 1, further comprising:
an armature, disposable in the bath and carrying the transducer arrays;
a rotational motor, coupled to the armature, to rotate the armature, and thus the
transducer arrays; and
a linear motor, coupled to the armature, to linearly displace the armature, and
thus the transducer arrays.

20 26. A device in accordance with claim 1, wherein the table and the bath are
horizontally displaceable with respect to one another between 1) a scan position in which the
table is disposed over the bath; and 2) a non-scan position in which the aperture is disposable
horizontally spaced-apart from the bath.

25 27. A device in accordance with claim 1, further comprising:
a drain pump, coupled to a drain in the bath.

30 28. A device in accordance with claim 1, further comprising:
a plurality of interconnected nodes, coupled to the transducer arrays, including
at least one compute node and at least one data acquisition node;
the at least one compute node including a single board computer and a fibre
channel host adaptor; and

the at least one data acquisition node including a single board computer, a fibre channel host adaptor, a waveform generator card, a data acquisition card, and a Mux card.

- 5 29. A breast scanning system configured to scan a breast of a patient, comprising:
- a) a bath configured to contain a liquid;
 - b) transducer arrays, disposable in the bath, configured to transmit and receive ultrasound signals;
 - c) a table, disposable over the bath, configured to receive the patient thereon,
 - 10 having an aperture formed in the table and positionable over the bath configured to receive the breast of the patient pendent therethrough;
 - d) a preconditioning tank, fluidly coupled to the bath, configured to precondition the liquid prior to being introduced into the bath; and
 - e) means for transferring liquid from the preconditioning tank to the bath.

- 15 30. A device in accordance with claim 29, further comprising:
- a heater, coupled to the preconditioning tank; and
 - a thermocouple, associated with the preconditioning tank and operatively coupled to the heater.

- 20 31. A device in accordance with claim 29, further comprising:
- a de-gaser, coupled to the preconditioning tank.

- 25 32. A device in accordance with claim 31, wherein the de-gaser further includes:
- a recirculation pump, coupled to the preconditioning tank in a circulation circuit to pump liquid from the preconditioning tank back into the preconditioning tank; and
 - at least one orifice, disposed in the circulation circuit having a diameter less than a diameter of the circulation circuit, and configured to introduce a pressure
 - 30 differential across the at least one orifice.

33. A device in accordance with claim 29, further comprising:
- a de-ionizer, coupled to a liquid supply line to the preconditioning tank.

34. A device in accordance with claim 29, further comprising:

a reservoir, fluidly coupled to the preconditioning tank, configured to contain an antibacterial or antiviral agent; and
a metering pump, coupled between the reservoir and the preconditioning tank.

5

35. A device in accordance with claim 29, further comprising:

the table and the bath being linearly vertically displaceable with respect to one another between 1) a lowered position where the table is adjacent the bath configured to position the breast within the bath, and 2) a raised position where the table is spaced-above the bath configured to elevate the breast above the bath; and

10

means for maintaining the table in the raised position with the table spaced-above the bath.

36. A breast scanning system configured to scan a breast of a patient, comprising:

15

a) a bath configured to contain a medium;

b) transducer arrays, disposable in the bath, configured to transmit and receive ultrasound signals;

c) a table, disposable over the bath, configured to receive the patient thereon, having an aperture formed in the table and positionable over the bath configured to receive the breast of the patient pendent therethrough; and

20

d) means for securing the breast within the bath.

37. A device in accordance with claim 36, wherein the means for securing the breast within the bath comprises:

25

a breast magnet with a breast connector configured to secure the breast magnet to the breast of the patient; and

a bath magnet, disposed in the bath and magnetically coupleable to the breast magnet when the table is in the lowered position.

30

38. A device in accordance with claim 37, further comprising:

a beveled cup, associated with one of the breast or bath magnets, to center the breast or bath magnets.

39. A device in accordance with claim 37, further comprising:

a rod, attached to the bath magnet and vertically movable within the bath.

40. A device in accordance with claim 39, further comprising:

an armature, disposable in the bath and carrying the transducer arrays; and
the rod extending through the armature.

41. A device in accordance with claim 36, further comprising:

the table and the bath being linearly vertically displaceable with respect to one another between 1) a lowered position where the table is adjacent the bath configured to position the breast within the bath, and 2) a raised position where the table is spaced-above the bath configured to elevate the breast above the bath; and

means for maintaining the table in the raised position with the table spaced-above the bath.

42. A breast scanning system configured to scan a breast of a patient, comprising:

a) a bath configured to contain a medium;

b) transducer arrays, disposable in the bath, configured to transmit and receive ultrasound signals;

c) a table, disposable over the bath, configured to receive the patient thereon, having an aperture formed in the table and positionable over the bath configured to receive the breast of the patient pendent therethrough; and

d) a plurality of table inserts, each insertable into the table and each having a different sized aperture formed therein.

43. A device in accordance with claim 42, further comprising:

an annular projection, formed around the aperture in the table, and extending beyond a lower surface of the table.

44. A device in accordance with claim 42, further comprising:

a counter-bore, formed in a lower surface of the table around the aperture, sized to receive an upper portion of the bath when the table is in the lowered position.

45. A device in accordance with claim 42, further comprising:

the table and the bath being linearly vertically displaceable with respect to one another between 1) a lowered position where the table is adjacent the bath configured to position the breast within the bath, and 2) a raised position where the table is spaced-above the bath configured to elevate the breast above the bath; and

5 means for maintaining the table in the raised position with the table spaced-above the bath.

46. A breast scanning system configured to scan a breast of a patient, comprising:

a) a bath configured to contain a medium;

10 b) transducer arrays, disposable in the bath, configured to transmit and receive ultrasound signals;

c) a table, disposable over the bath, configured to receive the patient thereon, having an aperture formed in the table and positionable over the bath configured to receive the breast of the patient pendent therethrough; and

15 d) an annular projection, formed around the aperture in the table, and extending beyond a lower surface of the table.

47. A device in accordance with claim 46, further comprising:

a plurality of table inserts, each insertable into the table and each having a
20 different sized aperture formed therein.

48. A device in accordance with claim 46, further comprising:

a counter-bore, formed in the lower surface of the table around the aperture, sized to receive an upper portion of the bath when the table is in the lowered position.

25 49. A device in accordance with claim 46, further comprising:

the table and the bath being linearly vertically displaceable with respect to one another between 1) a lowered position where the table is adjacent the bath configured to position the breast within the bath, and 2) a raised position where the table is
30 spaced-above the bath configured to elevate the breast above the bath; and

means for maintaining the table in the raised position with the table spaced-above the bath.

50. A breast scanning system configured to scan a breast of a patient, comprising:

a) a bath configured to contain a medium;

b) transducer arrays, disposable in the bath, configured to transmit and receive ultrasound signals;

5 c) a table, disposable over the bath, configured to receive the patient thereon, having an aperture formed in the table and positionable over the bath configured to receive the breast of the patient pendent therethrough; and

d) a counter-bore, formed in a lower surface of the table around the aperture, sized to receive an upper portion of the bath when the table is in the lowered position.

10 51. A device in accordance with claim 50, further comprising:

an annular projection, formed around the aperture in the table, and extending beyond the lower surface of the table.

52. A device in accordance with claim 50, further comprising:

15 a plurality of table inserts, each insertable into the table and each having a different sized aperture formed therein.

53. A device in accordance with claim 50, further comprising:

20 the table and the bath being linearly vertically displaceable with respect to one another between 1) a lowered position where the table is adjacent the bath configured to position the breast within the bath, and 2) a raised position where the table is spaced-above the bath configured to elevate the breast above the bath; and

means for maintaining the table in the raised position with the table spaced-above the bath.

25

54. A breast scanning system configured to scan a breast of a patient, comprising:

a) a bath configured to contain a liquid;

b) transducer arrays, disposable in the bath, configured to transmit and receive ultrasound signals;

30 c) a table, disposable over the bath, configured to receive the patient thereon, having an aperture formed in the table and positionable over the bath configured to receive the breast of the patient pendent therethrough; and

d) an annular channel, disposed around an upper edge of the bath.

55. A device in accordance with claim 54, further comprising:
a liquid sensor, disposed in the channel.

56. A device in accordance with claim 54, further comprising:
5 a seal, compressible between the bath and the table in the lowered position.

57. A device in accordance with claim 54, further comprising:
a pinch sensor, disposed between the bath and the table.

10 58. A device in accordance with claim 54, further comprising:
the table and the bath being linearly vertically displaceable with respect to one
another between 1) a lowered position where the table is adjacent the bath configured
to position the breast within the bath, and 2) a raised position where the table is
spaced-above the bath configured to elevate the breast above the bath; and
15 means for maintaining the table in the raised position with the table spaced-
above the bath.

59. A method for preparing a breast of a patient for scanning, comprising the steps of:
a) positioning the patient on a horizontal table;
20 b) disposing the breast through an aperture in the table;
c) linearly vertically displacing the table and a bath of medium with respect to
one another to immerse the breast into the medium; and
d) scanning the breast with ultrasound signals from transducer arrays.

25 60. A method in accordance with claim 59, wherein the step of displacing the table
further includes:
initially raising the table to a higher elevation; and
subsequently lowering the table to a lowered position adjacent the bath prior to
scanning the breast.

30 61. A method in accordance with claim 59, wherein the step of disposing the breast
through the aperture further includes:
selecting a table insert from a plurality of table inserts having different sized
apertures; and

inserting the table insert into the table.

62. A method in accordance with claim 59, wherein the step of displacing the table further includes:

5 receiving an upper edge of the bath into a counter-bore in a lower surface of the table.

63. A method in accordance with claim 59, further comprising the step of:

10 projecting a beam of light onto the breast to identify an area of interest to be scanned.

64. A method in accordance with claim 59, further comprising the step of:

 viewing an image of the breast including an area of interest to be scanned.

15 65. A method in accordance with claim 59, wherein the step of scanning further includes:

 sending and receiving ultra sound signals at a plurality of elevational locations along the breast, and at a plurality of rotational orientations around the breast at each elevational location.

20 66. A method in accordance with claim 59, wherein the step of scanning further includes:

 sequentially moving transducer arrays through a plurality of different elevational locations along the breast; and

25 sequentially moving the transducer arrays through a plurality of different angular orientations around the breast at each elevational location.

67. A method in accordance with claim 59, further comprising the steps of:

30 a) preconditioning a liquid in a tank; and

 b) transferring the liquid from the tank to a bath.

68. A method in accordance with claim 59, further comprising the steps of:

 storing data acquired by the transducer arrays; and

 simultaneously performing computations with stored data.

69. A method for preparing a breast of a patient for scanning, comprising the steps of:

- a) preconditioning a liquid in a tank;
- b) transferring the liquid from the tank to a bath;
- c) positioning the patient on a table over the bath;
- d) disposing the breast through an aperture in the table and into the bath; and
- e) scanning the breast with ultrasound signals from transducer arrays.

70. A method in accordance with claim 69, further comprising the step of:

maintaining a temperature of the liquid in the bath at a predetermined temperature.

71. A method in accordance with claim 69, wherein the step of preconditioning the liquid further includes heating the liquid to a predetermined temperature.

72. A method in accordance with claim 69, wherein the step of preconditioning the liquid further includes degassing the liquid.

73. A method in accordance with claim 72, wherein the step of degassing the liquid further includes re-circulating the liquid through an orifice, and creating a pressure differential across the orifice.

74. A method in accordance with claim 69, wherein the step of preconditioning the liquid further includes de-ionizing the liquid.

75. A method in accordance with claim 69, wherein the step of preconditioning the liquid further includes adding an anti-bacterial or anti-viral agent to the liquid in the tank.

76. A method in accordance with claim 69, wherein the step of transferring the liquid from the tank to the bath further includes filling the tank until the liquid overflows the tank into a perimeter channel surrounding the bath.

77. A method for preparing a breast of a patient for scanning, comprising the steps of:

- a) securing a breast magnet to the breast;
- b) positioning the patient on a table;

- c) disposing the breast through an aperture in the table;
- d) securing the breast within the bath; and
- e) scanning the breast with transducer arrays.

5 78. A method in accordance with claim 77, wherein the step of securing the breast further includes:

coupling the breast magnet on the breast to a bath magnet in a bath.

10 79. A method in accordance with claim 78, wherein the breast is immersed within the bath prior to the bath magnet being coupled to the breast magnet.

 80. A method in accordance with claim 77, wherein bath magnet is coupled to the breast magnet prior to the breast being immersed within the bath.

15 81. A method in accordance with claim 77, further comprising the step of:
 pulling on the bath magnet coupled to the breast magnet to tension the breast.

 82. A method in accordance with claim 77, wherein the step of coupling the breast magnet on the breast to the bath magnet in the bath further includes:

- 20 lowering the breast into the bath;
 raising a rod with the bath magnet thereon until the breast and bath magnets magnetically engage one another; and
 slightly lowering the rod to tension the breast.

25 83. A method in accordance with claim 82, wherein a length of the breast is determined based on a position of the rod and a position of the table

 84. A method for preparing a breast of a patient for scanning, comprising the steps of:

- 30 a) positioning the patient on a table;
 b) disposing the breast through an aperture in the table;
 c) immersing the breast into medium in a bath;
 d) initially more rapidly scanning a larger length of the breast with ultrasound signals from transducer arrays to identify an area of interest in the breast; and

e) subsequently more slowly scanning a smaller length of the breast around the area of interest with ultrasound signals from the transducer arrays.